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The Many Approaches to the Study of Monopolistic Competition

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1. DYNAMICS OR STATICS

In the concluding remarks in the opening chapter of Theory of Games and Economic Behavior von Neumann and Morgenstern (1944) note:

> "We repeat most emphatically that our theory is thoroughly static. A dynamic theory would unquestionably be more complete and, therefore, preferable. But there is ample evidence that it is futile to try to build one as long as the static side is not thoroughly understood. . . . A static theory deals with equilibria. . . . -- the relationship between statics and dynamics -- may be generically different from that of the classical physical theories."

They proceeded to develop a cooperative theory based upon the characteristic function of a game. Although in their developments they sketched out a procedure by which one could obtain the characteristic function by starting with the details of the extensive form, in both the development of solution theory and in application, the characteristic function can be regarded as given initially to the economist. In essence, by starting with the characteristic function, the economist has assumed away details of process, has hidden express consideration of the rules of the game and the institutions of the economy which serve as the carriers of process. In return for this simplification it becomes feasible to concentrate on the study of the combinatorics of potential coalitions.

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A different equilibrium approach is the one formalized generally by Nash (1951) and discussed in an economic context far earlier by Cournot (1897). The noncooperative equilibrium has played a dominant role in much of the work in oligopoly theory and associated topics.

Although the noncooperative equilibrium solution pervades many of the mathematical, verbal and diagramatic treatments of oligopoly, two distinct themes are present. They are explicit one period equilibrium analyses, often fully mathematized and implicit or explicit multistage models of competition where the dynamics of action and reaction are often described verbally or diagramatically. In either instance the game description required for the application of the noncooperative equilibrium calls for the strategic or extensive form (or an infinite multistage) representation of the game. In all of these instances the rules must be specified. A full definition of the game calls for the description of a process model. Thus, although the cooperative game solutions and the noncooperative equilibrium can all be regarded as equilibrium solutions, the former depend on models with the strategic structure surpressed, or at best implicit; whereas the latter calls for the strategic or extensive form.

Some time ago, in attempting to describe the study of the dynamics of oligopolistic competition, I suggested the title "Mathematical institutional economics" (Shubik, 1959). The reason for this paradoxical title is that if an economic environment and players are modeled as a game in extensive or strategic form, the institutions of the economy are reflected in the rules.

Much effort in modern industrial organization, corporate planning and competitive analysis has been aimed at the study of dynamics yet in many of the models and much of the writing the importance of lapsed time as a factor is hardly developed.

The economy dwells in the polity and the polity exists in the context of a society. The rules of one game which may appear to be immutable at one point of time may be modified in a larger context in the space of a few months, years or generations. There are games within the game. In actuality the rules of a single game which are reflected in the laws and customs of society as well as current tastes and technology are not immutable. They are subject to challenge by the players (we can get away with this); reinterpretation by the lawyers and judges and changes by the legislation or public at large.

It is suggested here that there are many highly different purposes for the study and application of theories of oligopolistic competition, monopolistic competition and allied topics. Before they can be criticized, or before suggestions can be made as to where we go from here, the different purposes and questions must be set in context.

2. WHAT ARE THE QUESTIONS?

2.1. A Disclaimer on Monopolistic and Oligopolistic Competition

Taxonomies are frequently highly useful in structuring thoughts. The phrase "monopolistic competition" suggested by Chamberlin (1933) called attention to the key aspect of differentiation of product (and firm) in competition among the few. Whether Mrs. Robinson (1933) really meant the same or not is, in my estimation, a topic best left to biographers and historians of economic thought. In the usage followed here, monopolistic competition covers oligopolistic competition and imperfect competition. The essential features being few competitors with strategic power, possibly differentiation, entry barriers and a

host of other "imperfections" such as humans with finite memories and abilities, indivisible goods, imperfect laws, less than infinitely fast markets and so forth.

2.2. Nine or More Related Topics for Investigation

Nine topics are noted here. No attempt has been made to be exhaustive or to produce completely mutually exclusive categories. Those selected are suggestive of much of the work currently in progress. The topics are listed and then discussed briefly.

(1) Static one period partial equilibrium oligopoly theory;

(2) The reconciliation of general equilibrium and static oligopoly theory;

(3) The new industrial organization;

(4) Regulation, contracts, law and economics;

(5) The structure of the firm, information, incentives and agency;

(6) Empirical institutional studies;

(7) Corporate strategic analysis;

(8) Behavioral theories of the firm and competition; and

(9) Experimental gaming

(1) Static one-period partial equilibrium oligopoly theory

For those who like their oligopoly theory straight there is a broad selection of well defined mathematical models of games in strategic form which have been built and still remain to be built. The original duopoly models of Cournot, Bertrand, Edgeworth and Hotelling can all be regarded as games in strategic form with pure or mixed strategy noncooperative equilibria. This is also true for much of the work of Chamberlin

Stackelberg and Mrs. Robinson. But even with Cournot and certainly with Chamberlin, Stackelberg, Fellner and the writings on "kinked oligopoly demand" the verbal argument is oriented towards dynamics.

The straight mathematical economist has many nice clean questions which can be asked in the context of a well-defined model of a game in strategic form. An exploration of price, quantity or price and quantity as strategic variables; an investigation of quality differentiation or differentiation via the selection of location in a world with costly transportation all are worth noting.

Although entry, advertising, innovation and purchase of capacity all are clearly relevant to the understanding of oligopolistic competition and although they can be modeled as though they were one shot games in strategic form (see, for example, Nti and Shubik, 1981a; Schmalensee, 1983); in essence, there are many features of the items noted which call for considering dynamics.

The verbal treatments of Chamberlin's large and small groups, Stackelberg's reaction curves; Bain's barriers to entry all are able to tell a better story than the formal games in strategic form. But the cost of the more plausible explanation comes at the price of a less precise analysis. In a verbal treatment it is easy to slurr over details such as the nonuniqueness of equilibrium points in even the simplest of entry models (see, for example, Nti and Shubik, 1981b, 1983). This applies to contestable markets (Baumol, Panzer and Willig, 1982) where the assumption of zero entry and exit costs in general destroys uniqueness of equilibria in the one shot game (see Shubik, 1959, p. 132).

There is by now a large literature on spacial competition following Hotelling's original paper. This is attested to by the special issue of the Journal of Industrial Economics (Sept./Dec., 1982) devoted to this topic.

Questions concerning the relative importance of different strategic variables are made more precise by constructing a strategic form game. And the analysis of the game provides a useful way to carry out a sensitivity analysis.

(2) The reconciliation of general equilibrium and static oligopoly theory

The Arrow Debreu models of the Walrasian system are closed and are not process models. Even the simplest of games in strategic form may be interpreted as a process model. It tells us what the feasible set of strategies is for each individual and its specifies what the outcome of the game will be regardless of equilibrium considerations.

Until recently almost all of the work on oligopoly theory has been done assuming a partial equilibrium context. Triffin (1940) tried somewhat prematurely to embed the monopolistic competition model into a general equilibrium system, but did not succeed. In the past ten years considerable progress has been made in doing so, this is discussed in Section 3 below.

Among the more important questions are:

(1) For a finite number of firms are the noncooperative equilibria generally inefficient?

(2) Can we construct Cournot and Bertrand-Edgeworth models which converge to the general equilibrium model as the number of competitors grows large?

(3) How do we describe the degree of differentiation among products as the number of monopolistic competitors each with a different commodity becomes large?

(4) How do we describe entry in a closed model?

(5) Can we model and solve a closed model of monopolistic competition with transportation costs on the sphere?

The recent survey of O. Hart (1983a) deals with many of the latest developments in oligopoly theory. The comments here are designed to supplement rather than duplicate his.

(3) The new industrial organization

The new industrial organization is amalgam of good empirically oriented microeconomics combined with operations research, management science and modern marketing theory. Here a few of the types of questions it seeks to answer are noted.

(1) What are useful measures of concentration?

(2) Can we measure oligopolistic inefficiency?

(3) What is the effect of the need to search on pricing?

(4) How optimal are the various rules of thumb used in different industries?

(5) How do production, capacity, inventorying and pricing conditions interact in various industries?

(6) What are the barriers to entry?

The thrust of the subject is towards applied and somewhat mathematical economics with some bias in the direction of concern with regulation and

societal welfare; but on the whole with much of the work not directly espousing a regulatory or an individual firm's point of view. The text of Scherer (1980) provides an excellent example of the approach, the type of questions and an increased concern with quantification.

From the viewpoint of the mathematical economist all of the questions are in terms of partial equilibrium and most are formulated as one person optimization problems. When competition is dealt with explicitly, it is, in general, as some form of noncooperative equilibrium analysis ranging from the one-shot equilibrium to an equilibrium in a differential game (see Case, 1979 for instance).

Although there is extensive literature on bargaining and on cooperative game solutions, the formal application of cooperative solutions to industrial organization is slim.

(4) Regulation, contracts, law and economics; (5) The structure of the firm, incentives and agency; and (6) Empirical institutional studies

Possibly growing faster than the new industrial organization has been, the burgeoning literature on law and economics especially in the United States where it has provided economic arguments for both regulation and deregulation of industry. Journals such as the Journal of Law and Economics and the (now reincarnated) Bell Journal of Economics provide examples.

Tied in closely with much of the above has been a concern for the internal structure of the firm especially a recognition of limits on information and control. Furthermore, there is now a growing appreciation

of the problem of the design of incentives in a hierarchical system and the occasion of need for a hierarchical system as an alternative to a price system. The work of Williamson offers a perceptive and primarily verbal discussion of the organization of the firm (see Williamson, 1975), the work in agency theory (see, for example, Ross, 1973), nonsymmetric information (see, for example, Green, 1983), and contract theory (see, for example, Grossman and Hart, 1984) is considerably more mathematical. The mathematical formulation of these problems generally involving the Bayesian updating of subjective probabilities in a sequential game utilizing a specialized noncooperative equilibrium solution such as the alternative to a perfect equilibrium suggested by Kreps and Wilson (1982).

The questions asked are of considerable concern to society:

(1) What are the criteria to be used to decide that a firm is too big?

(2) When is regulation (deregulation) called for?

(3) How are the incentives to be designed to keep fiduciaries acting in the best interests of their constituents?

(4) In what sense can the best interests of a heterogeneous group of stockholders be defined?

(5) What is the economic basis for contracts?

Yet although much wisdom starts with knowing what are interesting and good questions, it is desirable to be able to answer them. In doing so, we must distinguish between the development of a general theory from which answers to these questions can be derived and the proliferation of

ad hoc models designed to bolster the plausibility of the testimony of expert witnesses.

I suspect that prior to the construction of an adequate general theory many ad hoc models need to be built. At least at this time the type of verbal theorizing offered by Williamson combined with a detailed specific industry study and ad hoc* econometric investigations have far more to offer the courts and society in general than do the theoretical writings in oligopoly theory.

(7) Corporate strategic analyses

In the past thirty years there has been an explosion in the utilization of corporate strategic planning procedures. Samples of the publications which contain an intermix of organizational considerations, management science, operations research, computer simulation and economic theory are given by the works of Ansoff (1965), Lorange (1980), Naylor (1980), Porter (1980), and Shubik (1983).

Leaving aside the organizational aspects, (which are often critical for the actual manager) from the viewpoint of the economic theorist, much of corporate strategic analysis may be regarded as industrial organization theory turned on its head. Instead of looking at firm behavior from the viewpoint of regulation or academic curiosity, the bias in analysis is introduced from the viewpoint of the firm. The type of questions asked are:

(1) How can I optimally enter market x?

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* I wish to stress that I use ad hoc in a positive and not in a negative sense. It frequently stands for knowing your business in detail.

(2) What determines the decision to acquire an existing firm or start up fresh in a new market?

(3) What is the optimal form of integration?

(4) What is the optimal way to exit from a declining market?

(5) What are the tradeoffs between market expansion and antitrust costs?

Neither corporate vice presidents nor MBA students in a hurry to join a strategic planning consulting firm appear to have much interest in the existence or nonexistence of pure strategy perfect noncooperative equilibria in Bertrand-Edgeworth oligopolistic structures. We must ask is it because we do not yet know how to teach the correct basic oligopoly theory to practitioners or could it be that the theory is not yet sufficiently developed that except for a few concepts such as best response or threat, it is hardly of consequence in daily application?

In the United States there is an important and growing market for the services of the academic as a consultant and expert witness. The experience gained in being paid to work on real specific problems is undoubtedly of great value in building up a body of insight into the workings of actual industry. But it appears to be premature to judge whether this has yet had a significant influence on a theory of monopolistic competition. Perhaps the gap between ad hoc dynamics and a predominantly general static equilibrium theory is too large to be bridged in any great generality at this time.

(8) Behavioral theories of the firm and competition and (9) Experimental gaming.

The last two items on the list are explicitly process oriented and hence institutional. The process is constrained by the rules of the game be they technological, legal or societal. The process is manifested in the behavior of mechanisms and the mechanisms are the institutions of the economy, polity and society.

The seminal work of Simon (for a broad sampling see Simon 1979), March and Simon (1958), Cyert and March (1963) and other members of Carnegie Institute of Technology together with the building of the Carnegie Technology business game appeared to signal the development of a fundamentally new approach where the economist's narrow (and possibly irrational) penchant for rational behavior (well defined only in a highly restricted domain) was challenged and was to be replaced.

Although this work was started around thirty years ago (Simon's paper "A Behavioral Model of Rational Choice" appeared in 1955), the operational concept of "satisficing" as contrasted with optimizing still remains illusive. Yet in spite of the will-o'-the-wisp aspects of satisficing it is broadly felt by practitioners and consultants that rules of thumb are representative (as Baumol and Quandt, 1964 have phrased it) of optimally imperfect decisions.

The book of Nelson and Winter (1982) represents a continuation and extension of the school of the behavioral theory of the firm. It sketches the dynamics of innovation and offers sensitivity studies of simulations of the growth of industries. Yet in spite of many individual

insights the central theoretical basis for the rules of thumb, short cuts and behavior strategies does not yet exist. The problem reduces to the development of a theory of behavior of finite capacity machines required to behave in bounded time. And not only do we not have clear questions and answers, many economists are unaware that this is a central problem at the core of the development of modern psychology and artificial intelligence.

These comments are not meant to detract from the work of Nelson and Winter and the growing volume of corporate simulations (see, for example, Rosenkranz, 1979). It is possible that progress will eventually be made by the concerted efforts of those building specialized process models of many specific firms and industries developing insights into rules of thumb which work well in limited domains and devising explanations as to why they work.

Related to but considerably different from the work in behavioral theory and simulation has been the experimental approach evinced in activity in experimental economics (see Shubik, 1975a, 1975b, Smith, 1962, 1979, 1982 and Plott, 1982).

In the context of simple simulated markets, some of the virtues of the price system appear to be demonstrable by experiment. The evidence in favor of the noncooperative equilibrium or for that matter any game theoretic solution concept in general is poor. Institutional structure and the specifics of context and mechanism are far more important than appear to be generally recognized.

3. SOME ANSWERS: STATICS

3.1. Oligopoly in a Closed Economy

In Section 2 a broad sketch of the many approaches to monopolistic competition was provided in order to set the context for the questions and answers noted here without offering spurious generality. In particular, I suggest that several questions of central interest to the mathematical economist are of little concern to those dealing with policy and applications of the study of industrial organization.

How does one model oligopolistic competition in strategic form in a closed model? What is the relationship between the competitive equilibria and noncooperative equilibria of a closed economic system modeled as a game in strategic form? These two questions can be answered and can cast further light on our understanding of the Walrasian system, prices and noncooperative equilibria.

Shapley and Shubik (1967), Gabsewicz and Vial (1972) produced nonsymmetric models of games in strategic form where the consumers are regarded as price-takers. Shubik (1973) and Shapley and Shubik (1977) produced symmetric models of exchange modeled as a game in strategic form with markets and the use of a money.* These models

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* The main thrust of this article is on the study of monopolistic competition, its relationship to general equilibrium and the value of and difficulties with the noncooperative equilibrium solution. It would detract too far from our major purpose to include a lengthy discussion of the relationship among the theory of money and financial institutions, oligopoly theory and general equilibrium. But it would be remiss to fail to point it out.

In essence, the general equilibrium system is not fully defined as a game in strategic form. Little attention is paid to describing the system in disequilibrium. The act of modeling either the Cournot or Bertrand-Edgeworth models of oligopolistic competition (or variants with product differentiation, entry etc.) calls for specifying a game in strategic form. A natural simplification which makes this easy to do is to restrict the model to one market per commodity and to invent a money, credit and bankruptcy rules. Basically, the introduction of money and financial institutions and the embedding of oligopolistic competition into general equilibrium are closely related problems (Shubik, 1984).

are members of a general class of strategic market games which provide game or mechanism models of a closed economy. There are many technical difficulties to be faced in modeling production, entry, price strategies, product variation, but the loose coupling provided by markets, money and credit rules makes this simpler than it would be otherwise.

The formulation of a game in strategic form is a preliminary step which must be taken before we can well define a noncooperative solution concept. But the explicit definition of the game does not imply that the noncooperative equilibrium should be adopted as a solution concept.

3.2. The Reconciliation of Noncooperative Oligopoly Theory and General Equilibrium

The noncooperative equilibrium (N.E.) solution of Nash is a natural generalization of the Cournot oligopoly equilibrium which can be applied to any game in strategic form. Let there be n players, each player i has a set of strategies S_i and a payoff function $P_i(s_1, s_2, \ldots, s_n)$ where $s_i \in S_i$ is a strategy of i from his set. A noncooperative equilibrium $(s_1^*, s_2^*, \ldots, s_n^*)$ is such that if i is informed of the strategies of all others (let $s = (s_1, s_2, \ldots, s_n)$ and (s/s_i) be s without s_i) then

$$\max_{s_i \in S_i} P_i(s^*/s_i) \text{ implies that } s_i = s_i^* \text{ for all } i .$$

The key property of the N.E. is that of stability against the optimal response of any individual. This is different from the competitive equilibrium where the individual is assumed to make his decisions based on prices over which he has absolutely no influence.

If we assume that there is a continuum of economic agents each of which is of measure zero, then it can be shown that the noncooperative equilibria of the strategic market game coincide with the competitive equilibria of the related general equilibrium model (see Postlewaite and Schmeidler, 1978, Dubey and Shapley, 1977, Dubey, MasColell and Shubik, 1980).

Although the formal mathematical models can "reconcile" oligopoly theory and general equilibrium theory via strategic market games with a continuum of economic agents, it is my opinion that the difficulties with this reconciliation involve the modeling not the mathematics. In particular, the key concepts behind the competitive market are powerlessness, mass anonymity and irrelevance of strategic information. The basic factors central to oligopolistic competition are the power of few players and the importance of strategic information as well as the low likelihood of anonymity.

When there are at least two competitors of each type, the competitive equilibria of an economy represented as a strategic market game with price competition (Bertrand-Edgeworth) can be shown to be noncooperative equilibria (Dubey and Shubik, 1980, Dubey, 1982) immediately. Thus, for a fixed finite number of products and firms, the Bertrand-Edgeworth strategic market games appear to be more competitive than the Cournot games.

But with say only two or three competitors in a market even though the model and the logic of the mathematical analysis may be accepted, a new problem arises. Do we accept the solution concept? If there are

only two or three large players who are known to each other, why should they play noncooperatively? We return to this in Section 3.3.

If all firms are genuinely monopolistic competitors, each sells a differentiated product, then Bertrand-Edgeworth results cannot be obtained (see Hart, 1983a, b, c). The Bertrand-Edgeworth strategic market games provide a striking exception to the general results of Dubey and Rogawski (1982) who have shown the generic inefficiency of noncooperative equilibria for games with a finite number of players.

Novshek and Sonnenschein (1978) have been able to introduce entry into a closed model. By considering firms with a slight nonconvexity in production, that is small relative to the overall market epsilon-noncooperative equilibria can be obtained. This provides an endogenous determination of the size of industry.

In a closed system, as everyone has to be somewhere, the concept of entry is at least one that involves comparative statics, if not dynamics. We begin with everyone somewhere, change a parameter and see who moves in or out of production.

3.3. The Reconciliation of Cooperative Oligopoly Theory and General Equilibrium

The two major divisions of game theory solutions are cooperative and noncooperative. The former are associated with games in coalitional form and the latter with games in strategic or extensive form. The core, value, nucleolus, bargaining set and stable set solutions are the major solutions which are applied to games in coalitional form. They have been explored extensively in application to market games (for a summary

and review see Shubik, 1984). For the most part the results which show convergence of large finite game solutions for the core and value to the competitive equilibria, or which show equivalence results for games with a continuum of agents, are in reference to exchange economies. When items such as production and manager run firms are considered, the modeling problems in the coalitional form become considerable and are not yet settled.

Aumann (1973), Shitovitz (1973, 1974) and others have considered exchange economies with an ocean of traders and one or several atoms (i.e., large traders). Results concerning advantageous and disadvantageous outcomes in the core have been obtained. But without going into any discussion of these results an overall comment concerning the models and solutions is made. At the formal mathematical level important connections between the core and value of strategic market games and the related competitive equilibria have been made. These results confirm our intuition that if there are many competitors and none is large that details concerning strategies and institutions do not matter. But among few producers the investigations of the game in strategic form show that the results in general depend upon the specifics of the strategy sets. In the current investigations this detail has been ignored. If we merely regard market games as a mathematical structure, study their core (value) properties and compare them with the related exchange economy, we may say that formally general equilibrium and oligopoly theory have been reconciled. I suggest, however, that the characteristic function (in either its sidepayment or nosidepayment versions) is inadequate for the substantive modeling

of monopolistic or oligopolistic competition. If we wish to consider games in coalitional form to study oligopolistic competition, then we need to derive the coalitional form from a strategic form.

4. SOME PROBLEMS: DYNAMICS

The essence of monopolistic or oligopolistic competition involves few firms with some form of communication or signaling in a multistage game. Although there are some nice and relevant problems for the theorist to clean up in showing logical consistency between strategic market games and other closed economic models, these are not the major problems at this time.

The general equilibrium model was not suited for the study of oligopoly theory or of dynamics. It was and is a parsimonious construct designed to answer different questions. The strategic market game is more general than the general equilibrium model in the sense that the full strategy set for each agent must be defined.

It is possible that there are still many questions concerning oligopoly which can be answered using a game in strategic form but for the most part the development of further analysis appears to call for models of games in extensive form or in another form which is adequate to represent the information and moves and other sufficient details needed to consider dynamics.

Unfortunately, even for the game in strategic form and certainly for the extensive form the intuitive appeal of the noncooperative equilibrium point as a solution is far less than it might appear from an examination of a Cournot duopoly model with a unique symmetric noncooperative equilibrium.

4.1. Variations on Noncooperative Equilibria

The story told to support the competitive equilibrium is one of individual maximization under certainty or under uncertainty with individuals as risk neutral or risk averse and able to obtain any mix of insurance needed via futures markets (or adequate stock markets in a more complex model). As all prices are given, there is no strategic problem and no regret in having to reconcile ex ante and ex post strategic rational behavior. These features do not generalize to games in strategic or extensive form with a finite number of players.

The competitive equilibrium (under the appropriate conditions) can be proved to be Pareto optimal. It is, however, not generally unique. When there is no uniqueness unless one wishes to subscribe to a selection process such as that suggested by Harsanyi and Selten (1982), there is no endogenous way of selecting among the equilibria.

The argument for the competitive equilibrium can be phrased both normatively and behavioristically. Given prices people should optimize and as a first approximation given prices and more or less complete markets they do try to optimize.

When, however, we move to the noncooperative equilibrium the normative argument is considerably weakened, the empirical evidence from oligopolistic studies is not clear and the experimental evidence with games in strategic form shows only weak support of the best response property of the noncooperative equilibrium as the only property considered in determining individual "rational behavior" in a nonconstant sum $n(>1)$ person game.

The great virtues of competitive markets are that they are faceless and in theory uninfluenced by individual behavior. The sociology, psychology, social psychology and politics of the situation is killed by the mechanism. The strength of the price system in the context of the mass anonymous market is that the other factors of society do not matter. A major contribution of game theory has demonstrated that many different solutions lead to the same outcomes, this tells us that if the structure of a market is appropriate one can be extremely crude in assumptions made about motivation. The core, value, nucleolus and noncooperative equilibrium theories will all lead to competitive prices. Information leaks will not matter and free communication among groups will not influence the outcome.

When we assume that there are only few large actors present, all of the different game theoretic solutions give different predictions. Details count and the economist cannot ignore the need to justify choice among solution concepts.

We confine our comments to the noncooperative equilibrium (NE) and present a brief list of possible properties or desiderata. They are discussed in some detail elsewhere (Shubik, 1981). We may desire:

(1) Existence: sometimes there are no pure strategy NEs (see also Dierker and Grodal, 1982).

(2) Uniqueness: in general the NEs are not unique.

(3) Symmetry: there may be nonsymmetric NEs for symmetric games.

(4) Value: the different NEs to not necessarily have the same value.

(5) Pareto optimality: in general the NEs are not Pareto optimal.

Sensitivity analysis properties are important. We might wish to consider sensitivity to:

(1) Perturbation in payoffs.

(2) Perturbation in moves and strategies (trembling hand).

(3) Perturbation in information.

In general, games in strategic or extensive form do not display smooth changes in the NEs against perturbation in payoffs or small errors in the choice of moves. Furthermore, for games with a finite number of players, changes in information may make considerable differences. This is illustrated by the Cournot duopoly where Players 1 and 2 move simultaneously, where 1 moves first and where 2 moves first.

Selten introduced the concept of the perfect noncooperative equilibrium for games in extensive form. He subsequently introduced the idea of "trembling-hand perfection" to take care of situations in which some part of the game tree might never be reached. Krebs and Wilson (1982) have offered the concept of sequentially rational noncooperative equilibrium. At first sight these modifications appear to offer an important restriction on the set of noncooperative equilibria and might be regarded by some as particularly "rational". The argument being made in essence is based upon a backward induction which totally ignores threats as "irrational", but by the same token we could regard any code of behavior which fails to conform to local individual short run optimization as irrational.

I suggest that the strength of the perfect equilibrium analysis lies precisely away from the study of oligopoly or reputation or agency

but when there is a continuum of agents. It is then that threats do not matter. This supplies the justification for treating a multistage strategic market game with a continuum of traders as though each faced a one-person dynamic program with the market providing prices.

When numbers are few, there is no justification to excluding open threats as less rational or reasonable than subgame local optimization (see Shubik, 1959, Chapter 10 and Anderson, 1984).

4.2. Exogenous Uncertainty and Subjective Probability

Bayes' theorem must be regarded as a contribution to pure logic. Once the assumptions regarding the model are accepted, the way new information should be utilized to update current expectations should be in accord with Bayes theorem. But where the initial subjective probabilities came from and how we completely revise our cognitive maps of a situation are not part of the logic, but a basic part of how we structure our view of the change in the causal model invoked by new information. Schumpeter's description of competition and Shackle's concept of "potential surprise" are both examples of this. The introduction of new products such as the fastner Velcro or the 1-2-3 spreadsheet provide examples where once the additional information was available the whole cognitive maps of the competitors were changed.

A development of this topic would lead us far from the consideration of monopolistic competition alone. Two key survey references are noted. They are those of Abelson and Levi (1983) and Machina (1983). Before we invest too much intellectual capital on Bayesian games, it is

desirable to consider the scope of reasonable modeling. The conceptualization of new product introduction and consumer preference formation for new products is based at best on tentative knowledge.

4.3. Nonsymmetric Information

There has been a considerable growth in the literature on decisionmaking with nonsymmetric information. The surveys of Radner (1982) and Green (1983) cover much of the work. My comment here is merely cautionary. When the number of competitors is few, the conclusions of the rational expectations literature may be false (see Dubey, Geanakoplos and Shubik, 1982). But leaving that aside, from the game theoretic viewpoint in order to mount the theoretical apparatus of the noncooperative equilibrium, we have to accept not merely the noncooperative equilibrium as a solution concept, we must add on top Bayesian updating and some form of subgame perfection. Although I do not subscribe completely to either the kinked oligopoly curve analysis or to the tit-for-tat strategy discussed by Axelrod (1984), both of these appear to me to naturally reflect long run threats simply and more plausibly than the variants of perfect equilibria.

Are the solutions on variations of sequential equilibria to be regarded as normative or behavioral? Or are they meant to be some blend? If so, what is the blend? Furthermore, what is the justification for any belief that the failure to carry out short term expensive threats is globally rational?

5. FUTURE DEVELOPMENTS

It is my contention that as soon as we become concerned with economic dynamics we must consider mechanisms. But mechanisms implicitly define institutions. Thus, in a basic way further developments of mathematical economics in the study of competition must recognize that the rules of the game and institutional structure are highly related even at the highest level of abstraction. Hence, the search for minimal economic institutions is called for. A way to go about this is to build the simplest playable game in which the essence of the function appears. Thus, we must be concerned with the minimal representation of the manager–run–firm, bank, consumer, market and insurance company (among others).

I suggest that gaming has at least three functions. They are in experimentation, teaching and as an aid to model building and verification in theory construction. In particular, in the construction of games portraying oligopolistic markets the game construction methodology forces the economist to make explicit the assumptions concerning the legal and socio-political environment. Thus, for example questions of economic efficiency are asked in the appropriate context of legal and socio-political feasibility and costs.

Applied economics never abandoned institutional knowledge. The courts will survive quite adequately with whatever blend of ad hoc study and theory is available. The legal process is pragmatically oriented. It is more concerned with rationalizing what has happened (as good or bad) than upon developing any theory of rational behavior.

Thus, the economic theorist (as contrasted with the consultant in industrial organization, antitrust or corporate planning) has no burning applied problem to be solved immediately. We can ask where are the new paths to be followed. I suggest four topics, three of which are general to economic and game theoretic analysis and the fourth is specific to the theory of oligopolistic competition.

The four topics are:

(1) The study of subjective probability and risk behavior including the concept of threat.

(2) The construction of games with players with limited capacity.

(3) The development of experimental gaming to test current and new solutions.

(4) The development of oligopoly models combining explicit financial and capital goods structure with stress upon the role of time lags.

The first two involve interacting with psychology, social psychology and artificial intelligence. The third calls for a mixture of experimentation and theory and an explicit program to not merely check noncooperative behavior but to suggest and consider alternatives to the noncooperative equilibrium. Specifically, I suspect that a coincidence of properties (such as symmetry, Pareto optimality, uniqueness and best response) all improve the plausibility of a prediction.

The fourth item appears to me at this time to offer the most profitable avenue to combine institutional insight, operations research and economic theory. Although, in general, noncooperative equilibria

may be profuse and the dynamics hard to describe; if a specific structure is imposed caused say by time lags in buying new capacity and bringing it into production; inventory, production and delivery lags; lags in financing; organizational lags and costs in getting into or out of business and other specific factors, then the dynamics will be highly constrained (see Shubik with Levitan, 1980). The important work of Bain (1956) was to a great extent successful due to his introduction of time associated facts of life relevant to barriers to entry. Explicit teaching and experimental game models utilizing computer simulations rich enough to incorporate capital structure yet simple enough to be consistent with analytical models merit further development.

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